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'LIGHTING THE HOMES OF TO-MORROW'

By J. B. CARNE, B.Sc. *(Member)*

(Paper read on Tuesday, March 14th, 1944)

SUMMARY.

The paper deals with the lighting of the homes of the 'million.' Using published and new statistical data, the author deduces the pre-1939 average weekly expenditure on artificial light and the level and quality of the illumination prevailing in the homes of the lower income group in the U.K. Suggestions are made for improving the quality of the lighting without increased expenditure, with emphasis on the influence of decorations, and a plea for efficient units designed in accordance with well-defined principles.

The author accepts the I.E.S. Code values, and concludes that attainment of them necessitates at least twice the pre-1939 expenditure on gas or electricity, for lighting. He contends that the use of higher levels will result mainly from precept and example and availability of low running-cost sources; but that very considerable and immediate improvement in quality of illumination would result from preferential taxation of suggested "Utility" units of approved design, and sympathetic action in regard to decorations by architects and building authorities.

Introduction

Home lighting has been the subject of papers and discussions before our Society on many occasions in the past. The lighting of the home, in which economy dominates the provision of necessities and amenities, has, however, in the author's opinion, seldom received the attention it deserves. Social surveys made during the past twenty years clearly show that the majority of homes in the country fall into this category, a fact which alone justifies special consideration of the problems concerned.

In the following treatment attention is centred on the artificial lighting of these homes. It should not be overlooked that the principles involved are as applicable to the rich as to the poor home, and that the suggested provisions for lighting might well serve as the basis for the lighting of homes of all classes.

Prospective considerations often lead us to the fanciful, but if we are to profit by such considerations reality must never be left far behind, and if we are to assess the true worth of the conclusions derived, we must view them in perspective with related considerations.

For these reasons it is proposed to deal somewhat circumstantially with "to-morrow" and "the home" before presenting the data on lighting, which is the expected feature of a paper before our Society.

"To-morrow"

First let us consider the special nature of the period with which we are concerned. The "to-morrow" we contemplate is the day when building a house ceases to be an indictable offence and becomes priority A1. We foresee it as a period of unprecedented opportunities coupled with unprecedented facilities, the day after battle —a time long regarded appropriate for improving the homes of the people. The following introduction to a book written in 1816 by Richard Elsam, architect, serves not only to remind us that the idea of improving housing on a large scale is not novel, but also that something more than the plan is necessary to make good housing an accomplished fact.

As one might anticipate, knowing that even to-day in exemplary models of well-designed houses provisions for artificial lighting are frequently neglected, there was no mention of this feature in Elsam's discourse. It is not known to the author whether the hints of this post-war planner of former days were taken, but some few years later, in 1843, the appalling housing conditions in some of our cities stimulated organised effort in slum clearance and rehousing. Pioneer work began in Liverpool at this date and housing improvements have been continued since, except during the world war periods, on either small or large scale. Between the wars approximately four million homes were built in this country, representing the rehousing of a quarter of the population. There

was for this record building no grand programme such as is now contemplated for the construction of a similar number of houses in a shorter period, and the lighting equipment which went into the major portion of these houses was regarded more as a selling feature than a necessity, ranking with a pure water supply and good sanitation. The second report(1) on Codes of Practice for building and civil engineering lead one to believe that in magnitude and comprehensiveness the plans for our to-morrow go far beyond anything of the kind yet formulated. Planning for to-morrow extends from that of town and country to the washer on the kitchen tap, aye, and to the lighting units for the home. Not for nothing, then, have post-war planning committee rooms buzzed and bookstalls creaked under the welter of reports and replanning literature. Let it be hoped that the cumulative effort and enthusiasm of reformers and designers since the days of Richard Elsam, will reap full reward. That lighting in the home is officially recognised as a basic amenity and is to be the subject of a code of good practice are facts which must be gratifying to our Society. Records show that from its earliest days the Society has paid attention to home lighting. Its Code has, since its inception, included a section on recommended values for the home. For the most recent expression of interest one has only to refer to Mr. Ackerley's Presidential Address of 1942, in which he urged "diffusion of light," particularly in the great field of the "community at large."

HINTS

FOR

IMPROVING THE CONDITION

OF THE

PEASANTRY.

NOW the blessings of peace are restored to these happy isles by the united efforts of our countrymen, who have bled in the field of battle to protect our civil rights and independence, it is the happy moment when we should turn our eyes towards the condition of the poor, and in particular to our interesting peasantry, whose comfort in every part of the united kingdom at the present period either more or less calls for attention; and, as monarchs, statesmen, and philosophers in all ages have concurred in opinion, that the riches of a nation are the people, and as the peasantry constitute so considerable a portion of our wealth, it is doubtless the duty of those in whose hands Providence has placed the means, to assist in promoting their welfare. The comforts and advantages derived in society by their laborious exertions, make it absolutely necessary that the greatest pains should be taken to improve their condition. It is therefore a subject of deep concern, that the miserable state of their habitations in many parts of these countries have never been seriously taken into consideration. —*Richard Elsam, 1816.*

"The Home"

It is understood that the building of four million homes and the reconditioning of eight million existing ones constitute the immediate post-war domestic building programme. These, then, will largely determine

the average home of to-morrow and are therefore the homes with which this paper is concerned. How well can they be lit? What of the average home of yesterday, how well was that lit?

When discussing standards and the methods of attaining them, reality demands that we take account of the economics involved. Where costs are concerned we cannot "slink round the corner murmuring, 'They have nothing to do with us.'" Such an attitude would be as equally irresponsible as that of a dietary adviser who would refer the housewife to "Mrs. Beeton" as a guide to war-time catering. The obligations of the lighting engineer in this respect are no less than those of the architect, who must plan according to the income of the prospective tenant.

What, then, are the relevant economics of the average household, and what were the lighting conditions in the average home of yesterday?

In trying to visualise the average home we must avoid making the common error of imagining our own particular home as approximating to the average. I have therefore drawn the following relevant data, set out in Table I., from official statistics and accepted authorities:—

TABLE I.

Source of data.	Class of home.	Average household income per week.	Average number in household.	Average number of rooms per household, excluding scullery and bathroom.	Average amount per household spent on light and fuel, per week.
New Survey of London Life and Labour(2)1929-30	Av. of 82% of working-class homes in London 1930.	£3 18s. 0d.	—	—	—
Investigation for cost of living index computation.(3)	Av. of 8,905 N.H.I. industrial workers in G.B. 1937.	£4 5s. 3d.	3.8	3.9	6s. 5d.
Investigation for cost of living index computation.(1)	Av. of 1,491 agricultural workers in G.B. 1937.	£2 17s. 11d.	3.8	4.0	4s. 11d.
Investigation for cost of living index computation.(1)	Av. 366 rural working-class in G.B. 1937.	£2 16s. 8d.	4.25	4.3	4s. 9d.
A handbook of statistics.(6)	Av. income 75% of total number of families in country 1937.	less than £4 per week	—	—	3s. 6d. to 5s. 6d.

Mr. Seebohm Rowntree (7) (8), the well-known sociologist, gives the following subsistence budget for a family of five in the autumn of 1936:—

Food	20s. 6d.
Rent	9s. 6d.
Clothes	8s. 0d.
Fuel and Light	4s. 4d.
Household	1s. 8d.
Personal	9s. 0d.
	53s. 0d.

In analyses of family budgets the expenditure on lighting is invariably

included in an amount covering "fuel and light." From an analysis (9) of the hourly gas output records of the South Metropolitan Gas Company it is possible to compute with some degree of accuracy average data on the lighting of 300,000 domestic consumers' premises in South London in 1931. These are as follows:—

Hourly gas rate for Lighting (1931) per domestic consumer.	Gas consumed per week for lighting. Average for year of domestic consumer.	Light output of source corresponding to average gas consumption. (Non-superheated burner).
2,500 B.Th.U./Hr.	0.55 Therm	936 lumens (corresponds to the output of between 1 B.S.4 and 1 B.S.4 + 1 B.S.1) burners.

A recent survey of 1,600 households (in which principal wage earners' wage was less than £5 per week) using electric lighting, made by the War-time Social Survey on behalf of the Department of Scientific and Industrial Research, provided the following data, which the author is permitted to quote:—

Room	Average size lamp in use*	Types of shade in use Expressed as proportion of total surveyed	
		Simple conical shade with bulb showing below	Translucent bowl
Working kitchen ...	40-watt	86%	10%
Kitchen living-room	60-watt	72%	14%
Living-room ...	60-watt	60%	21%

* In one-third of dwellings the size of lamps had been reduced since the war.

Study of the gas output curves referred to show that the average annual number of lighting hours per household is approximately 1,100.

Based on the foregoing data calculation shows that the cost of lighting to the average householder was an amount less than 40s. per year, or 9.2d. per week. The actual figure depends on the cost of fuel energy to the householder; the maximum quoted corresponds to fuel energy prices of 18d. per therm for gas and 6d. per unit for electricity.

The interdependence of the components of the household budget and the necessity for examining costs in domestic planning are only too well demonstrated by the following report (10) on an actual, but what is hoped a rare, case:—

"In a famous investigation some years ago into the effect of removing slum-dwellers from the centre of the comparatively small town of Stockton-on-Tees (70,000 inhabitants) to a new suburb on the outskirts, it was shown that the extra cost, in hard cash alone, of the amount of additional travel required of the workers was such as to lower definitely the standard of living and to increase quite shockingly the rate of mortality and the incidence of disease."

These data and quotations indicate that the average family budget allows little surplus money to meet the cost of higher standards in the basic necessities of life, and the approach to our problem must be made accordingly.

Decoration

The following extract from the report (2) of the Council for Art and Industry indicates clearly the type of decorations prevailing in the average home:—

"We have been especially concerned by the tendency towards dull and heavy colour schemes, both among individuals and among local authorities who are responsible for decoration in the new estates. We were advised on several occasions that the

general choice tended towards brown or towards a set of colours which has been described as the gravy colour scheme."

From the foregoing it seems reasonable to describe conditions of the average home, relevant to lighting, in the following terms.

The Average Home

A dwelling of four main rooms, decorated in the "gravy" colour scheme. During the waking hours of darkness the family of four persons generally occupying one room, artificially lit by a poorly designed unit, having a source output of approximately 750 lumens. The household income little above subsistence income and the expenditure on lighting up to 9d. per week (average throughout the year).

It would indeed be fortunate for the purpose of this paper if a truly representative photograph of the living room of an average home were available. The photograph in Fig. 1 is obviously not of the average home, but it does portray features of the lighting commonly found in homes. Some of the evils of congregating the whole family in a badly lit room are clearly depicted.

Fig. 1. The living-room of a humble home. Note the restricted use of space due to inadequate lighting.

The rather depressing picture which statistics have forced me to draw of the lighting of the average home certainly justifies Mr. Ralph Tubbs's contention that the "men at the hill-top should come back and show the people the way the true leaders have gone." That appreciable improvements can be effected at little cost there is no doubt, and in the following an endeavour will be made to set down possible ways of making them, the basis of such suggestions, and to give some guide to the costs involved.

Lighting

The term "lighting" covers not only the objective but also the subjective effects. It covers the illuminating performance and the visual effects.

Visual effect, the aim and the criterion of excellence of every lighting installation, depends in the home on illuminating performance of the lighting units, room decoration, and design of the units. The latter two factors, although less precisely definable than the former, are nevertheless equally important. In considering them we encounter that personal property, taste, and so reluctant are we to trespass on the freedom of the individual that some may feel that to limit in any way the choice of decoration or design in the home is to violate a basic rule of our constitution. Even so, it must be admitted that there are good and bad tastes and that education, especially by example, can play a great part in developing the good.

Fortunately, what can be regarded in decoration and design from our point of view as good is little, if any, more costly than bad, and for this reason these lighting factors will be dealt with before illumination levels and the performance of units.

Decorations

Lighting engineers have for many years stressed the value of light-coloured decorations for interiors. Such decorations not only give considerable aid to comfortable seeing by reducing contrast between parts of an interior and between the unit and its background, but they are essential to the creation of the bright

environment, which has proved to be important to the maintenance of good health. The contribution to the illumination intensity which a light interior makes depends, of course, on the proportion of the direct and indirect light from the unit used. Except when a markedly indirect unit is employed this contribution is not large, but even so it is sufficient to improve diffusion and soften shadows to a marked degree. Consideration shows that the smaller the interior the greater the influence of interior decoration on the lighting effects, and thus in dealing with home lighting special attention is due to this part of our problem.

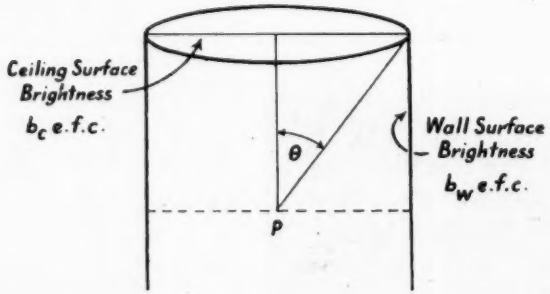
Illumination as Affected by Decoration of Walls and Ceilings

Comparison of the utilisation factors for various interiors, as set out in the tables used for design calculations, enable some idea to be formed of the effect of walls and ceilings on the horizontal illumination. Considerably more, however, is to be learned from calculations of the lighting of an average size room, which can be made provided certain approximations are conceded. The following example seems worth detailed attention.

The formulae (a) and (b), which are set out under Fig. 2 and can be easily deduced from first principles, give the horizontal illumination, at the point P, due to perfectly diffused light from a circular ceiling and from cylindrical walls respectively.

The formulae set down in Fig. 2 have been applied to a normal size room, as detailed in Fig. 3. In making the calculations no allowance has been made for inter-reflection between ceilings, walls, and floor, or for light reflected from the

CONTRIBUTION OF CEILING AND WALLS TO HORIZONTAL ILLUMINATION



H_c = horizontal illumination at P due to circular ceiling.

H_w = " " " P " " cylindrical wall.

b_c = surface brightness of ceiling in equivalent foot candles.

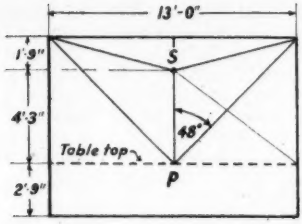
b_w = " " " walls " " " "

θ = angle subtended at P by radius of ceiling.

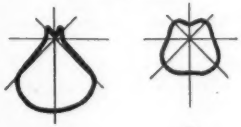
(a) H_c (foot candles) $= \frac{b_c}{2}(1 - \cos 2\theta)$

(b) H_w (foot candles) $= \frac{b_w}{2}(1 + \cos 2\theta)$

Fig. 2



Lighting Units



Output from each Unit 1,000 lumens

Floor dimensions 13'x 13'
Ceiling height .... 8'-9"
Table top level.... 2'-9"
Height of unit.... 7'-0"
Reflection Factor
Ceiling 80%
Wall 70%

CALCULATED ILLUMINATION IN A ROOM LIGHTED BY—
(A) DIRECT TYPE UNIT
(B) GENERAL " "

CALCULATED DATA

	(A) Direct Unit		(B) General Unit	
Average brightness of ceiling b_c	$0{\cdot}76 e f_c = 0{\cdot}0016$ c.p.□"		$1{\cdot}36 e f_c = 0{\cdot}003$ c.p.□"	
Average brightness of walls b_w	$0{\cdot}37 e f_c = 0{\cdot}0008$ c.p.□"		$0{\cdot}83 e f_c = 0{\cdot}0018$ c.p.□"	
	Intensity	% Total	Intensity	% Total
H_c = Horizontal illumination due to ceiling	0·42 f.c.	10%	0·75 f.c.	24%
H_w = Horizontal illumination due to walls	0·16 f.c.	3%	0·37 f.c.	12%
Horizontal illumination due to light direct from unit	4·0 f.c.	87%	2·0 f.c.	64%
Total horizontal illumination	4·58 f.c.	·····	3·12 f.c.	
Lumens thro' table top plane / Total lumens from unit	78%	·····	53%	

Fig. 3.

floor, or for obstruction of light by the unit.

It is of interest to compare the data calculated, and set out in Fig. 3, with the measured effect of wall and ceiling decoration on the illumination of a room lighted in turn by a direct and a general unit. The data given in Table II., below, refer to a room the walls of which were firstly "coral rose" (R.F. 62 per cent.) and secondly black (R.F. 2 per cent.), and the ceiling white (R.F. 76 per cent.) and then brown (R.F. 27 per cent.).

Room dimensions, 14 ft. 6 in. x 16 ft. 0 in. x 8 ft. 8 in.

Lighting unit central, 6 ft. 6 in. above floor.

Source output, 1,850 lumens.

When allowance is made for the differences in the output, reflection factors, etc., in the two sets of conditions, it is seen that the data theoretically derived are essentially of the correct magnitude, and they

serve to show the relative effects of the contribution of indirect light in the cases of the two types of units considered.

The reflection factors of "gravy" colours are of the order of 15 per cent., thus wall brightness and illumination contribution are approximately one-fifth of those given in the table in Fig. 3, whilst the contrast ratio between the unit and the wall is increased fivefold. The actual waste of light due to using "gravy" coloured, as compared with pale shade, walls is at least 10 per cent.

The effect of the different wall and

TABLE II.

Type of Unit and Output	Walls		Ceilings		Average horizontal illumination foot-candles	Difference in contribution to to horozontal illumination, % of Total.
	Reflection factor	Brightness	Reflection factor	Brightness		
Direct Unit ...	62%	0.8 e.f.c.	76%	1.2 e.f.c.	5.8	
	2%		76%		5.6	Walls 4%
1,550 lumens ...	62%		27%		5.2	Ceiling 10%
	2%	0.07 e.f.c.	27%	0.26 e.f.c.	5.1	
General ...	62%	1.7 e.f.c.	76%	2.8 e.f.c.	3.6	Walls 14%
	2%		76%		3.1	Ceiling 22%
1,450 lumens ...	62%		27%		2.8	
	2%	0.14 e.f.c.	27%	0.84 e.f.c.	2.5	

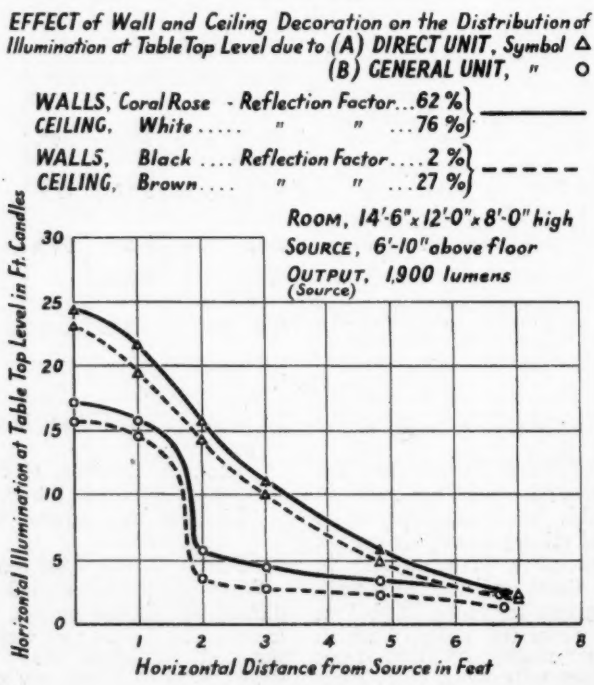


Fig. 4.

ceiling decoration on the illumination at table top level in the cases of a direct and a general type unit are seen in the graphs in Fig. 4.

Thus all lighting considerations lead to the condemnation of the popular "gravy" colour scheme. The argument that such a scheme keeps cleaner is of course false; light colours, in fact, encourage cleanliness by revealing dirt. Perhaps the most satisfactory compromise with this attitude is effected by having the dado a dark colour and the filling a colour of light shade.

Effect of Floor Reflection Factor on Illumination at table top level

In the average home the smallness of the free floor area in furnished rooms and the necessary use of floor coverings which are not easily marked, tend to minimise the effect of the floor on the utilisation of light. The economical use of house space is receiving the studied consideration of architects, and it is not unlikely that we shall see a wide adoption of the home plan containing one large living room for the family communal life and bedsitting rooms for the quiet use of the individual, in which eventuality the floor effect becomes worthy of mention. As a result of experimental investigation Lansingh ([11]) drew the following conclusions on the interaction of walls and floors so far as illumination at table top level is concerned:—

(1) With walls and floors, both 55 per cent. R.F., there is an increase on the working plane of 50 per cent. above what is obtained with walls at 11 per cent. and floor 2 per cent.

(2) The maximum increase obtainable from increasing R.F. of walls only is 25 per cent.

(3) The maximum increase obtainable from increasing R.F. of floor only is 15 per cent.

Other Subjective Effects of Wall and Ceiling Decorations

One does not have to be subject to claustrophobia to experience a distressing irritability when confined in a small room. The rooms in many of the houses and flats built in the "between-wars" period are undersized, and it is not at all improbable that as a result of a misguided policy of economy in building, the near future will see the number of such rooms greatly increased. Any means of alleviating the discomfort of those whose lot it is to occupy miniature rooms warrants attention, and the following subjective effects associated with lighting may be well worth exploiting.

A room appears smaller when its walls are glossy than when matt, and large patterns in dark colours also reduce the apparent size of a room as compared with the appearance with a plain light-coloured wall decoration.

Another effect which has practical application in the "make-do-and-mend" programme, in which as a result of dividing large rooms the smaller ones formed may have ceilings disproportionately high in relation to floor area, is that a ceiling darker in colour than its surrounding walls appears lower than when the reverse condition obtains. The extreme condition of this effect is the well-known "tunnel" effect experienced with totally direct lighting.

Design of Units

Excepting the crudest types of shades, good designs are cheaper than bad. We are still near enough to the 19th century to meet articles of that period daily and to find in many of recent production that excess of ornament which was the predominant characteristic of fashion and design of the Victorian age. The sophistication of popular taste resulting from the sudden material wealth which followed the industrial revolution markedly influenced the design of lighting fittings and units, even to this day. In the absence of well-defined principles of good lighting, ornamentation ran riot frequently at the expense of good performance. In the photograph in Fig. 5 we have a good example of the supremacy of decoration in the Victorian home, where each piece of furnishing vied with the remainder for command of the scene. The gas chandelier seen in the picture could have held its own almost anywhere, and whilst the lighting units on it were themselves the essence of sim-

plicity, being batswing flames in spherical opal globes, they were overwhelmed by the superabundance of refracting glassware on the pendant. It was possible to justify the dangling prisms common to fittings of those and later times by the desire to enliven the low brightness visual field resulting from the unaided units, but was it justifiable to obscure the downward light from a source already meagre in output? There is little doubt that utility was sacrified for decoration—for decoration's sake, a practice from which design has only recently begun to shake itself clear. Just prior to this war the principle of design which emerged from the reaction to the redundant and the elaborate was "fitness for purpose" or "functionalism," a principle which will doubtless dominate design in the home of to-morrow, for such design is economical and economy there must be.

Now a properly designed unit is the major factor in ensuring the practice of good lighting, and it is this which is lacking in most homes. Here, then, the lighting engineer can make a real contribution to good homes of to-morrow, for you cannot have "functionalism" in lighting unit design without a lighting expert—the principles of good lighting are too readily forgotten by anyone else. But "functionalism" is a narrow basis for design, and I cannot conceive a basis more generous and appropriate than Ruskin's dictum: "Truth first—plan, or design, founded thereon." Our scientific investigators have, by elucidating the main principles of good lighting, supplied the truth in our problem and in its solution; the distribution and degree of illumination, the brightness of surfaces, durability of performance, are all pertinent subjects for truth. How few units there are which can claim these in truth to be their basis! Is not the truth of them mostly subordinated to the densely coloured panel, the arty shape, the oversize tassel, or the metal scrollwork?

Here, then, is need for the co-operation of the lighting expert, the

Fig. 5. An Early Victorian Interior, showing elaborate ornamentation

designer, and the manufacturer, to all of whom the author suggests, for guidance, again the advice of Ruskin—advice which he gave more than half a century ago to the manufacturers of Bradford (12). "We require work substantial rather than rich in make, and refined rather than splendid in design. Your stuffs need not be such as would catch the eye of the duchess, but they should be such as may at once serve the need and refine the taste of a cottager." A policy which it has taken the privations of total war to make us adopt in the production of the essential articles of life, for is not this the basis of design of "Utility" goods? The suggestion is here put forward that representatives of our Society, of a recognised design authority, and of manufacturers should get together and produce "Utility" home lighting units, which are essential at the same time to the economical use of fuel energy and to the attainment of cheerful environment and good seeing in the home.

The availability of such units, purchasable free from tax, would, in the author's view, do more to raise the future standard of home lighting than any other single factor.

"Truth" in the Design of Lighting Units

Truth implies, amongst other qualities, efficiency; for a unit which belies the source cannot claim to be truthful in design. In adopting Ruskin's basis for design we have two main characteristics to satisfy—"functionalism" and "efficiency," on both of which depend economy.

The unit, therefore, should, in conjunction with its surroundings, provide a level of illumination adequate for the tasks to be performed; it should present a brightness, both in itself and its surroundings, which in no normal circumstances is discomforting and which promotes the mental attitude desired. In addition, the light from the source should be utilised consistently to these ends in an efficient manner. This last requirement involves such technical matters as minimisation of maintenance, accessibility of parts, and ease of assembly.

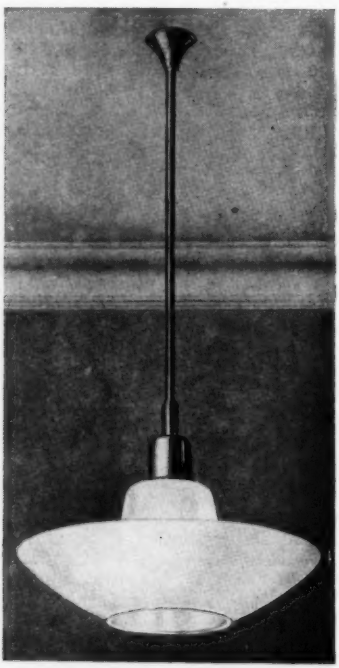
Success in the attainment of these desiderata depends of course on suitable materials for the making of units and on the sources available. The scope of designers will be considerably widened by the availability of new plastics and the fluorescent tube. Some time will elapse before such new articles will be commonly found in the home under consideration, but it is not likely to be unduly long, for the lag between the completion of an invention and its use in the home is negligible compared with the lag between the establishment of a principle and its practice in the home. Compare, for instance, on the one hand, the rapid entry into the average home of the incandescent gas mantle, the incandescent electric filament lamp, or the triode thermionic valve—only a few years elapsed between their creation in the laboratory and their common use. On the other hand, we are still waiting for the implications of Newton's "law of cooling" to be appreciated and acted upon by the builder who lays the exposed pipe under the kitchen floor, and for the lesson of the "Black hole of Calcutta" to be learned by those who construct unventilated bedrooms.

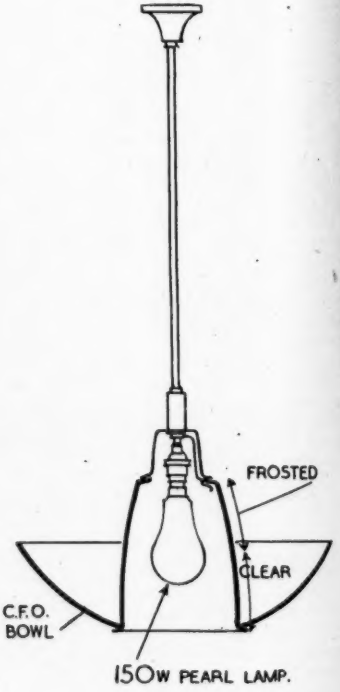
It is therefore principles with which we must be mainly concerned, for once they are appreciated and applied by user and designer alike, the best use will be made of novel materials and sources, from wherever they may come.

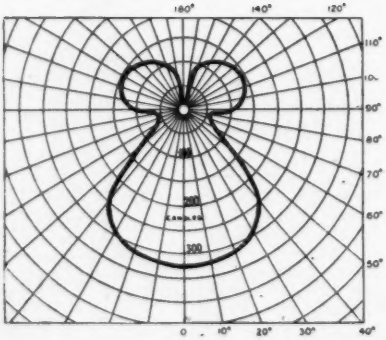
The units shown with their distribution curves in Figs. 6 and 7 each conform with the basis of design suggested; each is "fit for its purpose" and efficient, for the lighting of a living room. Illumination over a table area is provided by the unscreened source, whilst a good upward component over a wide angle illuminates the ceiling sufficiently to provide diffused general illumination over the whole room. At the same time the surround is of such opacity and extent as to prevent discomforting brightness to a person at any normal position in the room. The unit shown in Fig. 7 has the virtues of allowing maximum accessibility to the source and a minimum capacity for collecting dust. These two units of quite different decorative style demonstrate that "functionalism" does not necessarily cramp style. No

doubt a very varied range of units satisfying all tastes as well as the principle of "Truth," as here interpreted, could be designed.

From what has already been said it is clear that the room in which a unit is to be used must be considered when judging the excellence of the unit from the point of view under discussion. The spherical globe unit illustrated in Fig. 8 is of excellent functional design for a kitchen or other room in which only a moderate intensity of illumination is







On left: Distribution Curve for using 150-W Pearl Lamp. Efficiency of fitting 80%.

Fig. 6. "General" Fitting: Diffusing bowl with central aperture.

required at all parts. On the other hand a unit with a relatively greater downward component for local lighting over a sink would meet the demand for "fitness of purpose."

These remarks have been made with the view to dispelling any idea that the practice of "functionalism" necessarily sterilises the artistic urge. Many object to the word "functionalism" in that it is neither euphonious nor homely, but it has the merit of emphasising the necessity for keeping in sight, in our case, the primary aim of lighting. It also serves, as does that similarly objectionable phrase "machine-for-living-in" which le Corbusier devised for the home, to stir us from the "woolliness" which results from passive acceptance of the traditional.

The design of units has been dwelt on to some length because, in the author's view, correctly designed units will carry the principles of good lighting into the home.

Improvements and Costs

In the average home the decorated shades and bowls in common use have output efficiencies of the order of 60 per cent. and 50 per cent. of the same outputs respectively. Assuming the "gravy" colour wall decoration and an output of the source of 750 lumens as deduced earlier, calculation shows that in a room approximately 13 ft. square, the average illumination prevailing in the living rooms of yesterday's home was approximately 2.5 ft.c., with a table average of 6 ft.c. and the area beyond that covered by the direct light from the unit, having an average of the order of 0.5 ft.c.

Substitution of the 60 per cent. efficient shade by one of the type shown in Fig. 7 and redecoration of the walls with light colours would raise the minimum illumination to nearly 1 ft.c., improve diffusion, reduce glare, and increase the wall brightness eightfold.

The difference in the subjective effects of the two schemes is very pronounced, the comparison being well illustrated in Figs. 9 and 10.

To provide the levels of illumination recommended in the I.E.S. Code sources of greater luminous output and additional units for local lighting

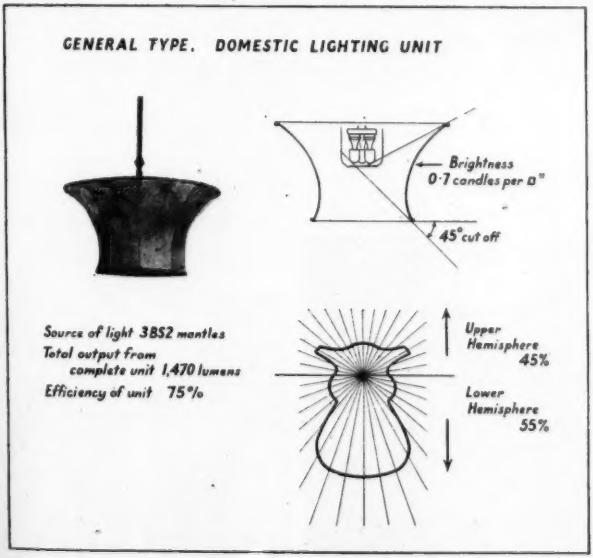


Fig. 7. A unit of good "functional" design which provides good local illumination beneath it, as well as general illumination.

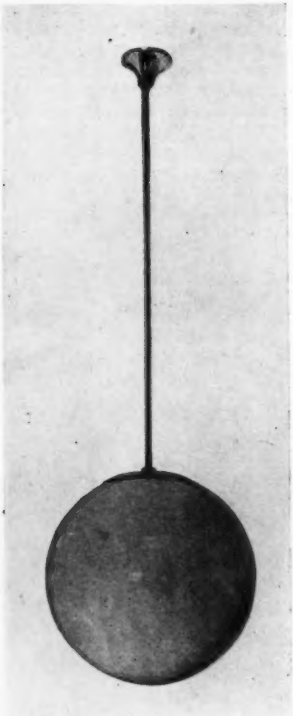


Fig. 8. A simple and efficient unit of good "functional" design for general lighting.

are required near the sink and the bed heads, as well as plug-in-points in the living room and bedrooms for standard floor or table lamp connection.

It is hoped that implementation of recommendations made in Codes and Practice will be general and thereby ensure the provision of an adequate number of lighting points and the installation of efficient units. The use to-morrow of sources which consume more energy, and are therefore more costly to run, will of course be the prerogative of the householder. Reference to the average "working-class" household budgets quoted earlier in this paper might lead one to suggest that a surplus shilling could be found in them to meet the increased cost entailed in raising yesterday's levels to those of the I.E.S. Code. However strong and convincing a case could be made to justify this expenditure, one cannot doubt that an equally strong case could be made for using that shilling to raise the standard of other necessities of life. Excepting the availability of cheaper light to the consumer, there appears little prospect of illumination levels in the principal rooms of the homes of to-morrow being little more than half those recommended in the I.E.S. Code, whilst as far as quality is

Fig. 9. Typical Interior Lighting of Yesterday, in room with sombre surroundings.

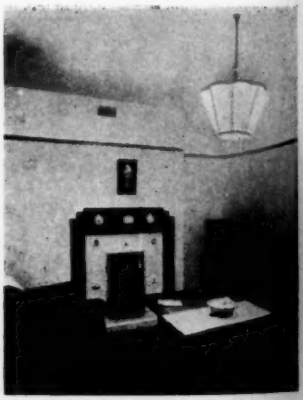


Fig. 10. Improved Interior Lighting in Room with lighter decoration.

concerned there are good grounds for anticipating a considerable improvement on yesterday's practice.

Costs of lighting to provide a given average intensity of illumination by the three main systems "direct," "general" and "indirect," are obviously inversely proportional to the utilisation factors of the three systems. Approximately these are in the ratios 1 : 0.7 : 0.5 and thus the relative cost for energy to provide a given average intensity are in the ratios 1 : 1.4 : 2. In actual practice, owing to the more comfortable quality of illumination resulting from the general and indirect units, such illumination, even with a lower average intensity is generally preferable to a higher average provided by a direct unit. Accepting some adjustment for this advantage of quality, the energy ratios become approximately 1 : 0.85 : 0.6 and the cost ratios of the three systems 1 : 1.2 : 1.75, or, in other words, lighting by general and indirect units is approximately one-fifth and three-quarters respectively dearer than by the direct unit.

Reduction to the householder in the cost per lumen, which is most likely to result from the introduction of the fluorescent tube, would, it seems from past experience, be followed by the use of higher illuminations.

Higher levels of illumination in the home have always accompanied the use of more efficient light sources; for when a householder changed from the flat flame to the incandescent mantle, or from the carbon to the tungsten filament lamp, he did not reduce his light bill to maintain the old level of illumination but rather did he maintain his bill and increase his illumination.

Education by precept and example will no doubt tend to induce those who can well afford to do so to use higher consumption sources and thus higher levels of illumination.

An Experimental Installation

Universal familiarity with domestic lighting probably accounts for the scarcity of recorded details on the illumination in dwelling rooms.

Some interesting data were collected recently of a trial installation in a four-room flat designed for the occupation of an artisan's family. These, and photographs of the installation which follow, bear pointedly on the issues discussed.

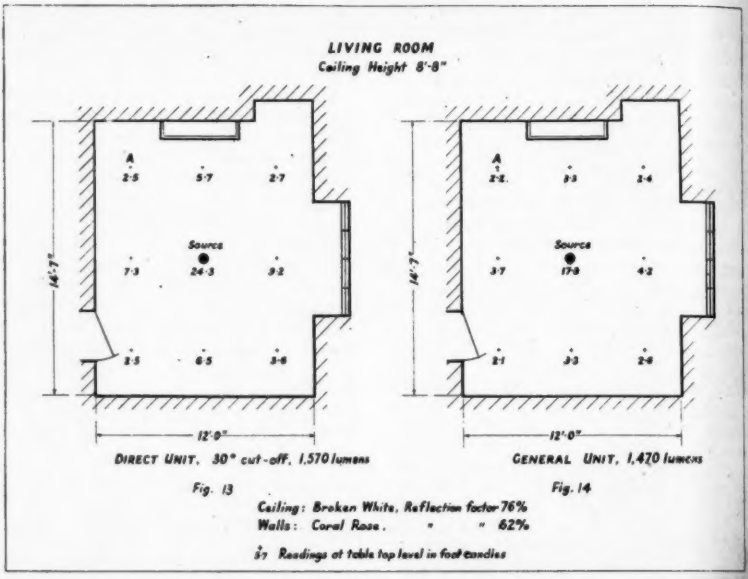
Living Room

Photographs shown in Figs. 11 and 12 are of the same room seen in Fig. 10, but illuminated by a source of 1,900-lumen output instead of one of 800-lumen output. In Fig. 11 the unit is of the direct type, being a shade effecting a 30 deg. cut-off of the source, and in Fig. 12 the unit is of the general type, similar to that shown in Fig. 7.

Figs. 13 and 14 give the corresponding illumination values measured at table-top level along the perimeter of an area equal to one half that of the room floor area. The advantage of the general unit cannot be judged from these illumination intensities alone. The proportion of indirect light from the surroundings,

Fig. 11. Lighting by "direct" unit. Note harsh shadows and contrast.

Fig. 12. Lighting by "general" unit. Note better diffusion and increased wall brightness.



which curves in Fig. 4 show, is more than 30 per cent. of the total at all parts other than the table area, must be taken into account. In spite of the lower intensity effected over the greater part of the room, opinion of experts and laymen alike was unanimous in favour of the general unit because of the better quality of the lighting. The softer shadows, due to a greater proportion of light being diffused from the walls and ceilings and the absence of abrupt changes of wall brightness with the general unit, is observable in the photographs in Fig. 12.

Referring again to Fig. 4 earlier in the paper, the marked difference in distribution of illumination in the two cases can be visualised from the graphs constructed from illumination readings at table top level.

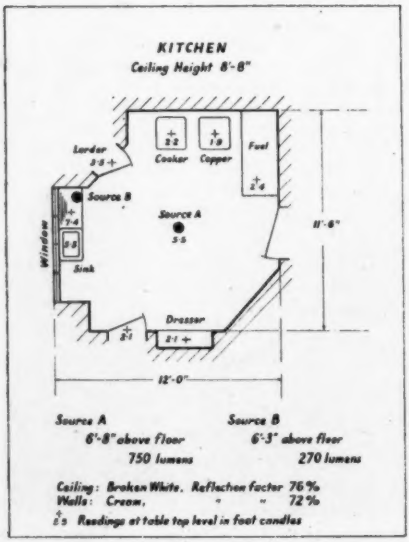


Fig. 15.

Kitchen-Living Room

Fig. 15 shows the illumination intensities resulting from the general unit, pendant from the centre of the ceiling, and a direct unit fitted near the sink. The importance of the second unit is clearly realised from the fact that it raises the illumination from 1.5 ft.c. to 5.3 ft.c. at the sink and eliminates the shadow of the worker due to obstructing the light

from the centre unit. The intensities provided by these units, having a combined output of 870 lumens, indicate that in this kitchen another unit near the cooker and an increase in total output of 75 per cent. would be necessary to attain the recommended values in the I.E.S. Code. Photograph in Fig. 16 shows the room used as a kitchen.

Bedroom

Good seeing at a dressing table requires light falling full on the face and on each side of it. In consequence, we almost invariably find the main unit and the dressing-table both placed in front of the window. Seldom is it realised that two great benefits of a window—the admitting of sunlight into the room, and the permitting of an open view of the outside world—are thereby nullified.

Where the window is so wide that such obstruction can be afforded, the centre window position is satisfactory; but where it is narrow, say less tnan 6 ft., the advantage of keeping it clear should be considered, and encouragement to this end can be made by fixing the unit at a convenient position clear of the approach to the window. The sketches of Fig. 18 contrast the effects resulting from the two arrangements.

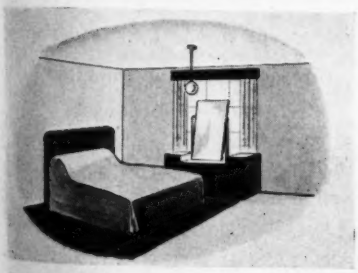
The economy of providing the illumination for the dressing-table and that for seeing into cupboards and drawers by means of one unit, necessitates the use of a unit with a good indirect component, and thus the shade is not appropriate for the main bedroom unit.

Dual-purpose Room

The advantage of plug-in-points in bedrooms in order to allow the use of a table standard so that a good intensity can be economically provided is illustrated in Fig. 18. The likelihood of planning to use the bedroom as a dual-purpose room, that is as a bed and a private study room, emphasises the importance of conveniently situated plug-in points and exemplifies the fact that adequate lighting and heating facilities allow the home to be used to its maximum capacity. This aspect of the value of lighting is rarely appreciated, and it cannot be too widely broadcast that in view of the fact that more than 50 per cent. of home life is spent in the waking hours of darkness stingy lighting virtually minifys the home, whilst liberal lighting facilities are essential to utilising a house to full capacity.

Publicity based on the analogy between the contraction of the area of

Fig. 16. Kitchen-living room, showing illumination of sink.



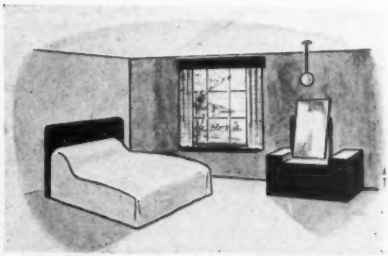


Fig. 17. Avoidance of obstruction of window by suitable positions of lighting fitting and furniture.

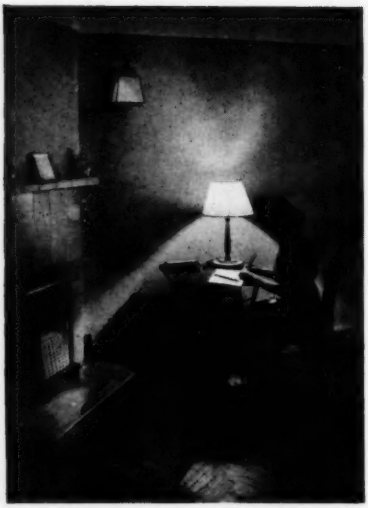


Fig. 18. Study lighting by table lamp.

activity of the individual due to the "black-out" and the corresponding effect in the home might well have a valuable educative effect on this aspect of lighting practice in the home of to-morrow.

Conclusion

In this treatment of the subject a prediction has been essayed of the lighting of the average home in the years immediately following the war. In such a critical period lighting engineers and others concerned with this small but important feature of post-war planning, should be fully cognisant of the essential details bearing on the problem, so that they may, whenever the opportunity arises, add their measured strength to the forces for improvement.

Summing up, it appears that considerable improvement in the quality of lighting will materialise, but this only through the sustained efforts of all those who appreciate the problems involved. How close the levels of illumination will approach the I.E.S. recommended standards of good practice depends in the main on the economics of the household budget. We cannot expect a transformation in conditions to take place with the rapidity of demolition effected by the "block-buster," and it is not unlikely that our to-morrow will be a transition period during which a moderate standard of living must be endured in order to create a basis for prosperity. In such a period the luxurious and purely decorative will be the property of the few and the vast majority of us will have to make the most of restricted resources.

Hard experience has demonstrated that only by a scientific treatment of each individual part of a problem can the maximum benefit be extracted from the whole. With lighting, as with all the other components of the "machine-for-living-in," the time is ripe for the application of the scientific attitude. The formulation of the codes of practice relating to building is evidence of authoritative recognition of this fundamental of successful reconstruction. It may well be that in the practice of the principles of good lighting we shall see the first evidence of the penetration of the scientific attitude into the Englishman's castle, a necessary preliminary to the achievement of the aims of housing reformers for centuries past. Thus we may yet witness the final stage of the process so brutally commenced in 1940, and so completely described by the Prime Minister [13] in 1925 in the following words:—

"I am convinced myself that the day will come when we shall have to eviscerate our great cities—a tremendous task, but one to which the imagination and the vision and the wisdom of the best of us may well be devoted. The task is enormous, and therefore it is all the better worth doing. I like to think that even at a time like this, when we are preoccupied with unemployment and the hardship arising out of it, we are yet giving our minds to try to raise up in this kingdom better, healthier, more beautiful communities than exist to-day."

Acknowledgements

In the preparation of this paper the writer has been permitted the use of illustrations provided generously and readily by the following:—

Fig. 1.—Reproduced from "Rebuilding Britain." (Published for

R.I.B.A. by Lund, Humphries and Co., Ltd., 1943.)

Fig. 5.—Reproduced from "Design," Anthony Bertram. (Penguin Books, Ltd.)

Figs. 6 and 8.—General Electric Company.

Figs. 9 and 10.—Gas Light and Coke Company.

He acknowledges with thanks the help received from these sources, and wishes also to record his appreciation of the valuable assistance of his colleague, Mr. S. F. Ebdy, who has kindly produced all the sketches and drawings.

The trial installation described was prepared by the South Metropolitan Gas Company, and the author desires to express his thanks to the directors of the company for allowing the use of data and photographs of it, and for permission to publish this paper.

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(2) "The Working-Class Home—Its Furnishing and Equipment." (H.M.S.O., 1937.)

(3) Weekly Expenditure of Working-Class Households in the United Kingdom in 1937-38. I. (H.M.S.O., 1941.)

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(6) "The Home Market." Harrison and Mitchell. (Allen and Unwin, 1937.)

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(10) "Town Planning." Thomas Sharp. (Pelican, p. 37.)

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(13) "On England." Earl Baldwin.

DISCUSSION

THE PRESIDENT said the author had usefully drawn attention to the economic, artistic, and aesthetic considerations in lighting the homes of the future. These were matters which illuminating engineers very often did not consider were their function, but the author had been very wise in calling attention to such points because there seemed some possibility that the ideas expressed in the paper—or some of them—might form the basis of future action.

Mr. R. O. ACKERLEY, commenting on the author's remark that in many respects good lighting was not more costly than bad lighting, said that very often it was simply a question of having the right fitting in the right place. The cost of lighting came under the two headings of capital cost—which had been something of a bugbear in the past, particularly in the case of homes already badly lighted—and running costs. As regards the former, this problem would largely disappear if the initial cost of the lighting installation were made part of the cost of the house, thus allowing it to be spread over many years. Proper installation at time of building would also tend to reduce capital cost. As regards the latter, he said the cost of light production had fallen steadily for many years and a great deal more light for the same money was now obtained than in the past. As a society, however, they should not over-weight the economic case, and they must try to convince people that good lighting was something which would benefit them in many ways. If the public—or certain sections of it—could not afford this good lighting then it would be necessary to convince the Government to give us a new social state by which people could afford essential social amenities, and good lighting would be one of them. Perhaps, also, the public should be urged to have better lighting and fewer cigarettes.

On the technical side, he said he was surprised that the author had made no reference to the provision of utility points in houses—points for several different jobs. One of the principal requirements of an electrical installation in a home was flexibility, and if there were plenty of utility points installed when the house was built then the degree of lighting could be changed from time to time. For instance, a standard lamp only could be used on occasion, and generally the light could be used more effectively and economically exactly where it was wanted.

The paper seemed to suggest that the manufacturers of fittings should get together and make what might be called a range of utility fittings. If he meant that suggestion as a war-time measure it was necessary to remember that manufacturers were not permitted to make any

fittings at the moment so far as the home was concerned. For the post-war period, he personally did not see the necessity for such a step as there was at present a big market for the very numerous designs of fittings that were available before the war and would be available afterwards at prices which the public could afford. Whilst it might be possible to influence public opinion, experience showed that it was impossible to dictate, and to put a range of utility fittings on the market suggested an attempt to dictate. He did not believe there would be any difficulty about the fittings problem. The important thing was to see that the fittings available fulfilled the requirements of giving reasonable illumination where it was wanted and that they had a reasonable over-all efficiency, and it was possible to pick dozens of fittings from the catalogues which met these requirements.

The Society could do something to ensure that suitable fittings were placed in the homes of the future. The first step was to try to see that when houses were built they were equipped with suitable fittings which were sold with the house. That would ensure the owner starting off with the right kind of fitting and that he would be likely to change only for better fittings. Therefore, the Society should try to ensure that the homes of the future were handed over complete with electrical installation and fittings. It was understood there were to be Codes of Practice for lighting in homes but they would not have any statutory authority, presumably, and, therefore, the Society must try to ensure that local authorities—who were themselves very big builders—should, when passing plans for their own houses or those of builders, insist that the Codes of Practice were carried out in their areas.

Mr. R. W. AMES said he was rather depressed by the first part of the paper, because he felt that the Society was more interested in what science could do in lighting homes rather than worried too much at this juncture as to how much it was going to cost the country as a whole. We had shown during the past five years that we could provide vast sums of money for war purposes, and surely, after the war, we could afford a little to make our homes worth while. In the past our statesmen had said a great deal about the home being the most important place, and they should certainly be made worthy of the men who came back from the war. In the past, few houses that had been built could be considered as the best design of their particular types, and in any case there had been very little progress in lighting the home during the past twenty years. More efficient light sources and fittings were available, but we did not seem to be getting anywhere with them. The architect was being urged to—and, indeed, would—design more beautiful houses in the future, but it would be little use doing this if engineers, rather than magnifying destroyed these beauties by bad illumination. There was a chance now which had never existed before, and we should, during the transitional period, overthrow all pre-conceived ideas on lighting and start afresh. There was the fluorescent tube, which at the moment, it is true, could only be made in the 5 ft. size for industrial purposes and was not available for the home, but there was little doubt that it would be available in various forms after the war. With this form of illumination it would be possible to build the lighting scheme into the original design of the house and thus to obviate superficial additions afterwards. With lighting thus made an integral part of the house, he doubted whether it would be found very much more expensive in the first place than the conglomeration of fittings which were now strewn all over the house. However, in this matter he did not think we should consider too much the immediate post-war period, because it was obvious that during that time we should have to tolerate many things and make the most of what was available. In the meantime, we should go on developing, and eventually take into account the undoubtedly great discoveries which had been made during the war.

Mr. A. H. OWEN said he also had been a little disappointed with the paper from the point of view the last speaker had mentioned. He was now busy on designing a scheme for his own home, which was a small bungalow, and for the living room he proposed to make use of fluorescent tubes to give 120 ft.c. and so get as near as possible to natural lighting conditions. The higher degree of illumination he proposed would not cost very much on the domestic power rate, which rendered possible the cheapest form of lighting that could be obtained. With the present domestic rate in his area one could burn a 100-watt lamp for nineteen hours at the cost of one cigarette, and therefore the economic aspect of improved lighting installations should not be overstressed.

Mr. E. G. GUYATT said that arising out

of the remarks of the last speakers he hoped the importance of the visual factor would be borne in mind. He did not know to what extent that aspect had been given attention by the Society, but the eye was a very delicate organ. The whole paper was directed towards creating something which would enable us to see better; but what was meant by "better"? It might be possible to carry out a certain task with a high illumination better than with a low illumination, but care must be taken not to damage the very delicate organism of the eye. There had been cases in which too much infra-red tended to develop cataract, and he did not think the effect of ultra-violet light was very well known yet.

Mr. J. S. Dow recalled that the very first paper the Society had, by Sir John Parsons in 1910, dealt with the eye and its response to light. Further, last year Sir John Parsons gave an address to the Society on "Light and Vision," so that the Society did not neglect that aspect. A good deal of evidence had been obtained in regard to the effect of intensity on the eye. Dr. Lythgoe, a physiologist who afterwards turned his attention to the physical side, had established that it was possible to go to very high illuminations without the ability to see suffering in any degree, provided the light was used judiciously and glare was avoided. The question of possible effects of infra red and ultra violet radiation had been raised many times in the past; in fact, whenever new forms of lamps were introduced. It was right that the effect of new illuminants should be studied, but he did not think there was any evidence of trouble from lamps at present in common use.

Referring to a few points in the paper, he said that the type of diffusing fitting with an opening at the bottom had proved very useful in small rooms and enabled quite a high illumination to be obtained at a moderate cost. In small rooms such as those illustrated there was a need for strong light in the centre only, as if, for purposes of calculation, a room was in effect reduced in size by half, i.e., from about 12 ft. square to, say, 8 ft. square (64 sq. ft. instead of 144 sq. ft.). Thus the required illumination could be provided over this "effective area" at a very much lower figure than if one adhered strictly to the watts per square foot requisite to illuminate equally the whole actual area of the room.

With regard to charging for lighting, he wondered whether, in the future, when such matters might be determined on a "social" rather than a purely economic basis, it might be possible to arrange tariffs on something like income-tax lines. In many fields the wealthier did, in fact, bear part of the cost which the poorer consumer could not afford (e.g., in the theatre, where the high prices for stalls and boxes enabled more moderate charges to be made in other parts of the house). In the supply industry the natural tendency had been to frame charges on an economic basis of so much for a certain number of units and less afterwards; conceivably this process might be reversed for the benefit of the poorer and smaller consumers by making the rate moderate for the initial "necessity units" and raising it for the extra amount of "luxury units."

Mr. E. STROUD referred to a recent instance in the Midlands of a local authority putting up two model cottages, for which it was stated that all that could be afforded by way of illumination was a flexible and the old type of conical shaped shade. This would seem a very short-sighted policy and a retrograde step, and he thought some action should be taken to advise local and home planning authorities on the more modern and efficient means available for the lighting of new homes for the reconstruction programmes.

Mr. G. A. WEDGE said he thought more could be done to develop the idea of building-in the lighting system when the house was erected, which should not add greatly to the cost and certainly improved the amenities of the house. As to fittings, he thought there were too many in the catalogues to choose from, and the choice seemed to leave everybody aghast and not knowing what to do. If the number could be reduced to about one quarter there would not be half the trouble there ordinarily was. Emphasising the desirability of the fittings being installed as part of the house when it was built, he said this would mean educating architects to an appreciation of the fact that the electrical installation must not, in future, be considered as costing no more than 5 per cent. of the value of the house. The cost of the installation, together with the lighting units, could be added to the price of the house and form part of the mortgage, where a mortgage was taken out. Then the house would be sold complete with lighting equipment just as it was sold with a domestic boiler.

Mr. J. B. CARNE, replying to the dis-

cussion, said he agreed with Mr. Ackerley that if the economic system did not allow the homes of the people to be provided with the essentials of life—and adequate illumination was such—then an alternative to the system was called for. He believed that running costs were the chief hurdle to overcome in raising the levels of illumination to the standards of the Society's Code. If costs were ignored then any kind of lighting to which the imagination ran could be proposed. Mr. Dow had suggested a novel way of reducing running costs to the low wage earners, but it did not seem a scheme likely to be adopted. He felt himself that the scheme of tax-free approved fittings was a practical possibility which, if realised, would effect a tremendous improvement in the quality of home lighting.

He disagreed entirely with Mr. Ackerley's contention that a range of such fittinges would serve no useful purpose. He felt that Mr. Ackerley's argument on this point rather proved the reverse. Mr. Ackerley had stated—and he agreed—that before the war there were many well-designed fittings in some makers' catalogues from which to choose; and yet the survey showed that relatively very few people had them in their homes. Such fittings would again be available after the war, but the point was that the vast majority of purchasers were not competent to discriminate between good and bad designs nor to assess quality. This accounted for the unsatisfactory state of affairs revealed in the quoted statistics on the types of fittings in use, and if some strong guidance was not exercised in the future a survey in twenty or thirty years' time would show no improvement. He was of the opinion that the purchase tax, which would no doubt be with us for many years to come, when used preferentially, was a "heaven-sent" device for directing people to purchase particular kinds of goods, and it should be applied in this way to lighting fittings, as it had been to many other essentials of modern life to the great benefit of the individual and the nation. By subsidising the good at the expense of the bad and shoddy, approved fittings would be brought more within reach of the millions of ex-Service men and others whose financial resources in the post-war years would be stretched to the limit.

It appeared to be inconsistent to decry the suggested utility scheme as being dictatorial and yet to advocate that homes should be ready fitted with the "right kind of fittings," so that the buyer or tenant must take over these with the house. This way of wrapping the fittings up with the house not only restricted choice of fittings but also the choice of house, without financial advantage to the buyer. It was also a method which catered for the new houses only, whereas the "utility" scheme would cover existing houses as well; and it should not be forgotten that even twelve years hence, when the proposed 4,000,000 new houses were built, there would still be three pre-war houses to every new one.

With regard to Mr. Guyatt's words of caution regarding the general use of sources in which a good amount of ultra-violet was generated, he agreed that this aspect should not be overlooked. It should, however, be considered that some millions of fluorescent tubes had been in use for the war-years and many thousands of people must have been exposed to them for many hours a day. Yet there had, as far as he (Mr. Carne) knew, been no epidemic of eye troubles, and unless such evils *did* arise it would be unreasonable to suspect these sources.

Built-in lighting units were lower in efficiency than some of the types he had shown, and, consequently, for a given intensity of illumination they were more costly to run. Where economics really affected the picture they were prohibitive for the reasons already given. He believed that it was intended that selling lighting equipment with the house was to be one of the features of the post-war building programme and, while he felt that everything should be done to ensure the installation of an adequate number of gas and electric points, he deprecated the inclusion of the actual lighting fittings for the reasons he had already stated.

I.E.S. Fellowship

The following application for Fellowship has been accepted:—

Lambert, G. E. V.

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